# *Diesel Engine Retrofit Technology Verification*

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# Outline

- Diesel Issues
- Diesel Retrofit Technology Verification Activities
- Test Results
- Actual and Potential Impacts
- VDRP and Clean Diesel Campaign

(Dennis Johnson, OTAQ, VDRP)

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# The environmental issue . . .

- 7.9 million heavy-duty diesel trucks and buses in the US
  - emit large amounts of particulate matter (PM), hydrocarbon (HC), and nitrogen oxide (NOx)
- These emissions contribute to:
  - Serious public health and environmental problems, including premature mortality, asthma aggravation, reduced visibility, etc.
  - Non-attainment of National Ambient Air Quality Standards (NAAQSs) in several areas of the country

# The environmental issue . . . (cont'd)

## Trucking enterprises

- Account for 30% of the transportation related PM emissions in the U.S.

## School buses

- Are also a significant source of diesel emissions
- > 24 million children ride a bus to and from school each day
- Children are particularly susceptible to diesel pollutants

# The response . . .

- An increasing recognition of importance of diesel engine emissions
- Resulted (in part) in the development/use of:
  - Regulations designed to reduce emissions from new diesel engines (Ex: 2007 Heavy-Duty Highway Engine Rule)
  - Voluntary programs designed to encourage the use of retrofit technologies and other emission reducing alternatives
    - Voluntary Diesel Retrofit Program (VDRP)
    - Smartway Transport
  - The use of emission reduction State Implementation Plan (SIP) credits in areas that are not in compliance with NAAQS (ambient) limits
  - Development of a # innovative technologies that can be used to retrofit diesel engines

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# ETV's response . . .

With input from OTAQ, CARB, and others, ETV's APCT Center (managed by RTI International):

- Developed three diesel engine retrofit protocols
  - Alternative Fuels, Additives, & Lubricants (Sept 2003)
  - Selective Catalytic Reduction (Sept 2003)
  - Exhaust Catalysts, Filters, & Engine Modifications (Feb 2002)
- These protocols are posted on the ETV and OTAQ Voluntary Diesel Retrofit Program (VDRP) Web sites
  - By working with VDRP and the ETV program, these protocols can be used by retrofit technology manufacturers interested in being included on the VDRP Verified Technology List

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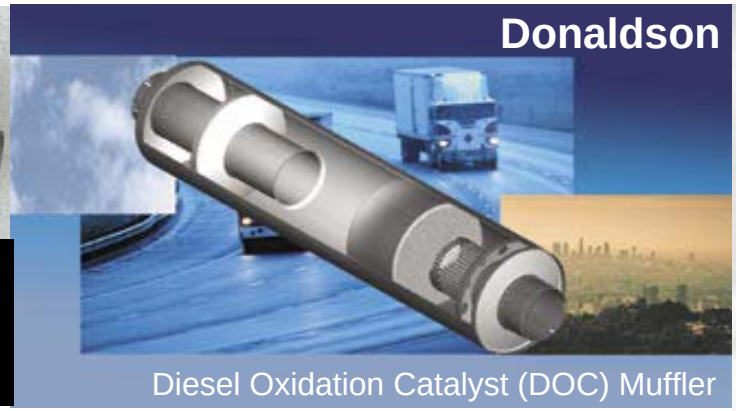
# ETV's response (cont'd)

- Verified seven diesel retrofit techs. in FY 03/04
  - Donaldson Company, Inc. (3 techs.)
    - Series 6100 DOC Muffler
    - Series 6100 DOC Muffler and Spiracle Filtration System
    - Series 6000 DOC Muffler and Spiracle Filtration System
  - Clean Diesel Technologies, Inc. (2 techs.)
    - FBC w/CleanAir System's DOC
    - FBC w/Mitsui/PUREarth CWMF
  - Lubrizol Engine Control Systems, Inc. (1 tech.)
    - Purifilter SC17L
  - Clean Clear Fuel Technologies, Inc. (1 tech.)
    - Universal Fuel Cell, Model CCFT21061 (No verification statement)

**Clean Diesel**
Oxidation Catalyst Muffler




Diesel Oxidation Catalyst (DOC) Muffler

**Lubrizol**

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# ETV Test Results - % Emission Reduction

## Ranges for Seven Technologies Verified

| Technology | PM** | HC | CO |
|---|---|---|---|
| A | 48 to 53 | 37 to 59 | 54 to 64 |
| B* | 29 to 34 | 0 to 42 | 31 to 35 |
| C | 77 to 76 | 88 to 90 | 58 to 74 |
| D | 86 to 95 | 88 to 100 | 71 to 87 |
| E | 22 to 28 | 49 to 66 | 38 to 41 |
| F* | 21 to 34 | 0 to 52 | 12 to 24 |
| G | No reduction | No reduction | No reduction |

* Technology included a crankcase vent filter

** Verified techs primarily intended to reduce PM

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# Potential impacts of verified technology use

## Environmental, health, and monetary

- Assuming 10% market penetration (e.g., 10% of the current fleet of heavy-duty trucks and buses use an ETV verified retrofit technology), ETV estimates
  - PM emissions potentially reduced by 8,980 to 31,300 tons after 7 yrs of use
- This relates to:
  - 683 to 2,380 avoided instances of premature mortality*
  - $5,150-$17,900 (millions 1999$) in associated monetary benefits* could be realized

*Via a comparison to PM-related impacts in the 2007 Heavy-Duty Highway Rule

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# Impacts of the ETV/VDRP collaboration . . .

- Developed three well accepted **protocols** for demonstrating emission reduction performance
  - Currently posted on both the ETV and OTAQ VDRP Web sites
  - Have helped to advance efforts to standardize testing
- Generated performance data that:
  - Have been used to post ETV-verified technologies on the VDRP Verified Technology List
  - Enabled verified vendors to "participate in many national voluntary retrofit programs" (in addition to VDRP)
    - Clean School Bus USA & various state programs (NYSERDA, etc.)
- Ultimately, should help reduce state- or program-specific testing requirements needed to:
    - demonstrate emission reduction performance
    - estimate pollutant reductions [e.g., to fulfill State Implementation Plan (SIP) requirements]

# Available marketing impacts . . .

- Clean Diesel Technologies, "Verification under the ETV Program has generated considerable commercial interest in our technology from end users as well as regulators and potential distribution partners."
  - Request for proposals to retrofit school buses and commercial fleets
  - Commercial orders from Coca Cola Enterprises (a Smartway Partner) to retrofit beverage delivery vehicles
    - Per Clean Diesel Technologies, "A small company would never be able to access Coca-Cola if they did not go through the ETV process."

# Available marketing impacts . . . (cont'd)

- Donaldson, "Obtaining EPA's ETV Verification has enabled Donaldson to participate in many national voluntary retrofit programs."
  - 1,100 verified retrofit devices for NY schools under the NY State Clean Air School Bus Program sponsored by NYSERDA
  - 100 school buses retrofitted under a grant from Clean School Bus USA to NYSERDA
- Lubrizol
  - Partnering with Pennsylvania DEP, Sunoco, and the Philadelphia Diesel Difference to retrofit 29 City of Philadelphia diesel vehicles

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# VDRP and Clean Diesel Campaign

Dennis Johnson, OTAQ VDRP

- Program/campaign overview
- Verification activities
- ETV/VDRP collaboration
- Interaction with other agencies (CARB, TCEQ)

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# Supplementary Slides

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# Diesel Retrofit/Mobile Source Technology Groups

- Devices
  - Diesel Exhaust Catalysts (DECs)
  - PM filters
  - Engine modifications
  - Other devices
- Fuels
  - Alternative fuels (emulsions, biodiesel)
  - Reformulations
  - Fuel additives
  - Lubricants and lubricant additives
- Selective Catalytic Reduction

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# Test Approach

- Based on FTP engine dynamometer tests
  - Minimum of 1 cold-start, 3 hot-start tests
  - Additional tests may be required to detect effect
- Results reported as mean and 95% confidence interval of emission reduction for each pollutant
  - If confidence interval includes zero reduction, then results cannot be distinguished from zero reduction
  - NOx, PM, HC, & CO are primary
  - Also CO2, fuel, and other operating parameters

# Test Approach (cont'd)

- Emissions reductions from engine certification level
- De-greened and aged technologies versus each type of engine
- Multiple engine testing required for broad applicability - EPA-OTAQ decision

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# Verification Process

- Manufacturer submits application.
- Verification team discusses application, test/QA plan.
  - Applicant
  - APCT Center
  - OTAQ
  - SwRI
- EPA approves test/QA plan.
- Applicant signs contract with APCT Center.
- APCT Center conducts verification test.
- APCT Center publishes report; posts to APCT Center and EPA ETV Web sites.

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# Roles

## ETV

- Coordinates testing with EPA-OTAQ
- Prepares test/QA plan
- Audits ETV test labs
- Conducts ETV tests
- Issues ETV verification reports and statements

## OTAQ

- Evaluates total application package
- Interprets emissions reductions data from ETV
- Sets emissions reductions for technologies and posts on VDRP Web site
- Extends applicability to other engines (and adds requirements for additional data)

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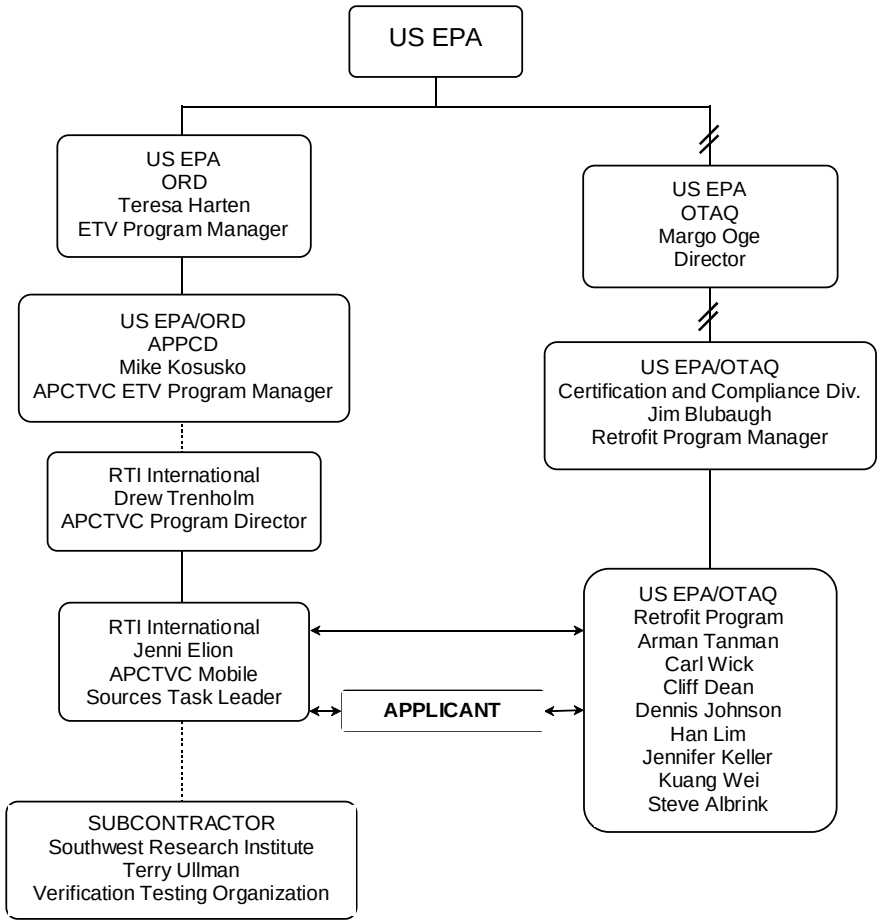
# Organization

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# APCT Center Interaction with Other Agencies

- Texas Commission on Environmental Quality (TCEQ) New Technology Research & Development (NTRD) Program
  - Retrofit add-on technologies;
  - Advanced technologies for new engines and vehicles that produce very low or zero emissions of NOx;
- California Air Resources Board (CARB) Memorandum of Understanding with EPA
  - Reciprocity in verifications of hardware or device-based retrofits.
  - Commitment to cooperate on the evaluation of retrofit technologies.

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# Information

| | |
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